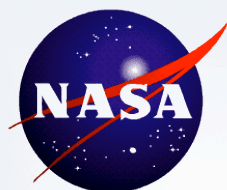
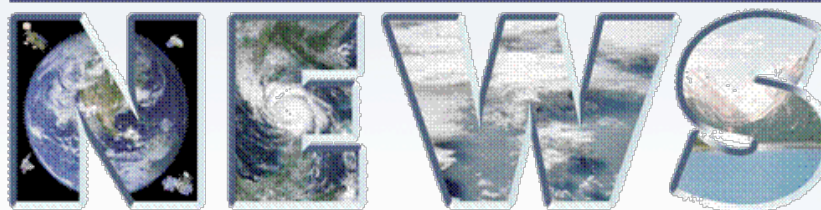


2010 Highlights



NASA ENERGY AND WATER CYCLE STUDY



NEWS Challenge:

Document and enable improved, observationally-based, predictions of water and energy cycle consequences of Earth system variability and change.

NEWS Working Group Co-Chairs

Program Manager: J. Entin (NASA-HQ)

Project Scientist: P. Houser (GMU)

Project Office: R. Schiffer (UMBC/GEST) &

Focus Area Liaison: D. Belvedere (UMBC/GEST)

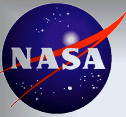
Drought & Flood Extremes: X. Dong & Y. Deng

Evaporation & Latent Heating: J. Famiglietti & C.A. Clayson

Energy & Water Cycle Climatology: M. Rodell & T. L'Ecuyer

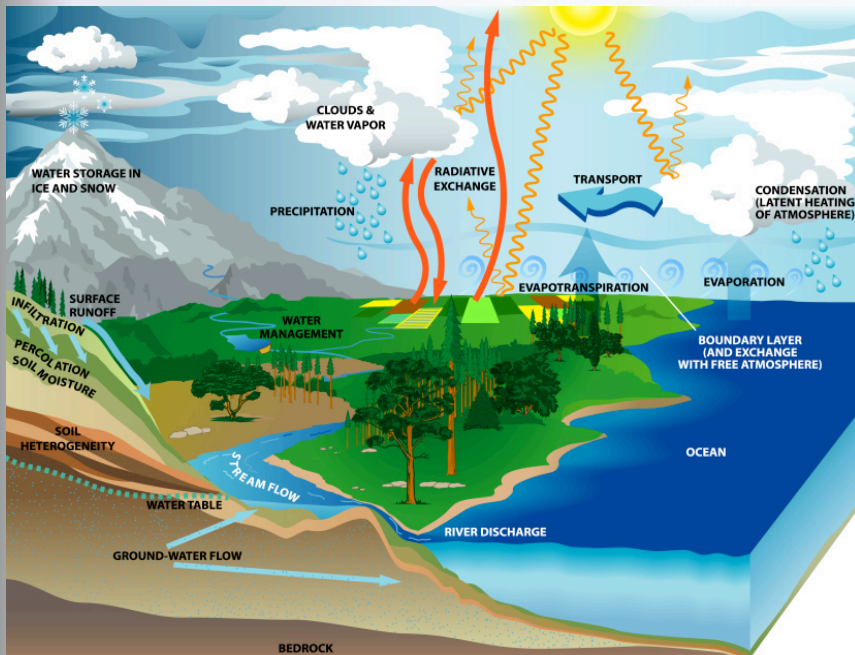
Modeling & Water Cycle Prediction: M. Bosilovich & Y. Hu

Want more NEWS? <http://www.nasa-news.org>



The Water and Energy Cycle

Is the water cycle accelerating?



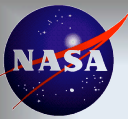
Why NEWS?

Need the collective of NASA & community information and expertise to ask (and define) the larger questions

(aka) Need the whole to be more than the sum of the parts

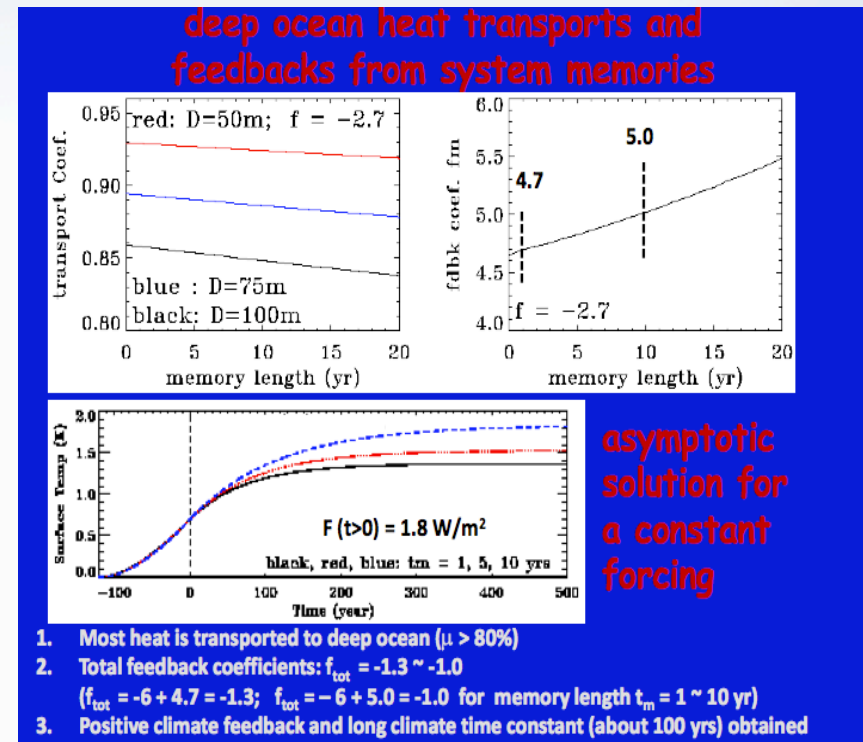
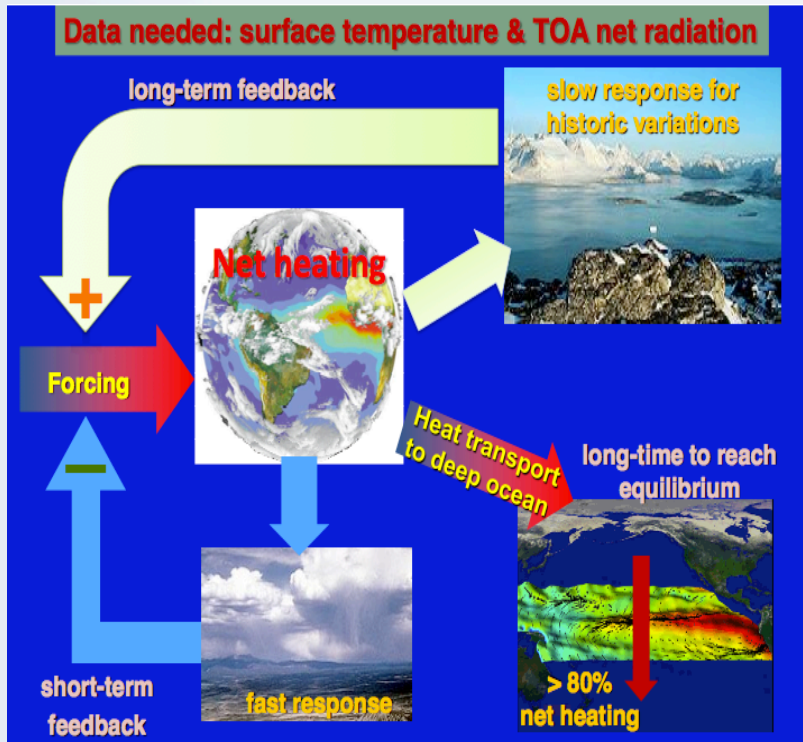
Why study the water & Energy cycle?

1. Water exists in *all three phases* in the climate system and the *phase transitions* are a *significant factor* in the regulation of the global and regional energy balances
2. Water vapor in the atmosphere is the *principal greenhouse gas* and clouds at various levels and composition in the atmosphere represent both positive and negative feedback in climate system response
3. Water is the *ultimate solvent* and global biogeochemical and element cycles are mediated by the dynamics of the water cycle
4. Water is the element of the Earth system that most *directly impacts and constraint human society and its well-being*.



NEWS Publication Highlight

B. Lin, L. Chambers, P. Stackhouse Jr., B. Wielicki, Y. Hu, P. Minnis, N. Loeb, W. Sun, G. Potter, Q. Min, G. Schuster, and T.-F. Fan, Estimations of climate sensitivity based on top-of-atmosphere radiation imbalance, Atmos. Chem. Phys., 10, 1923–1930, 2010. (Published: 19 February 2010)



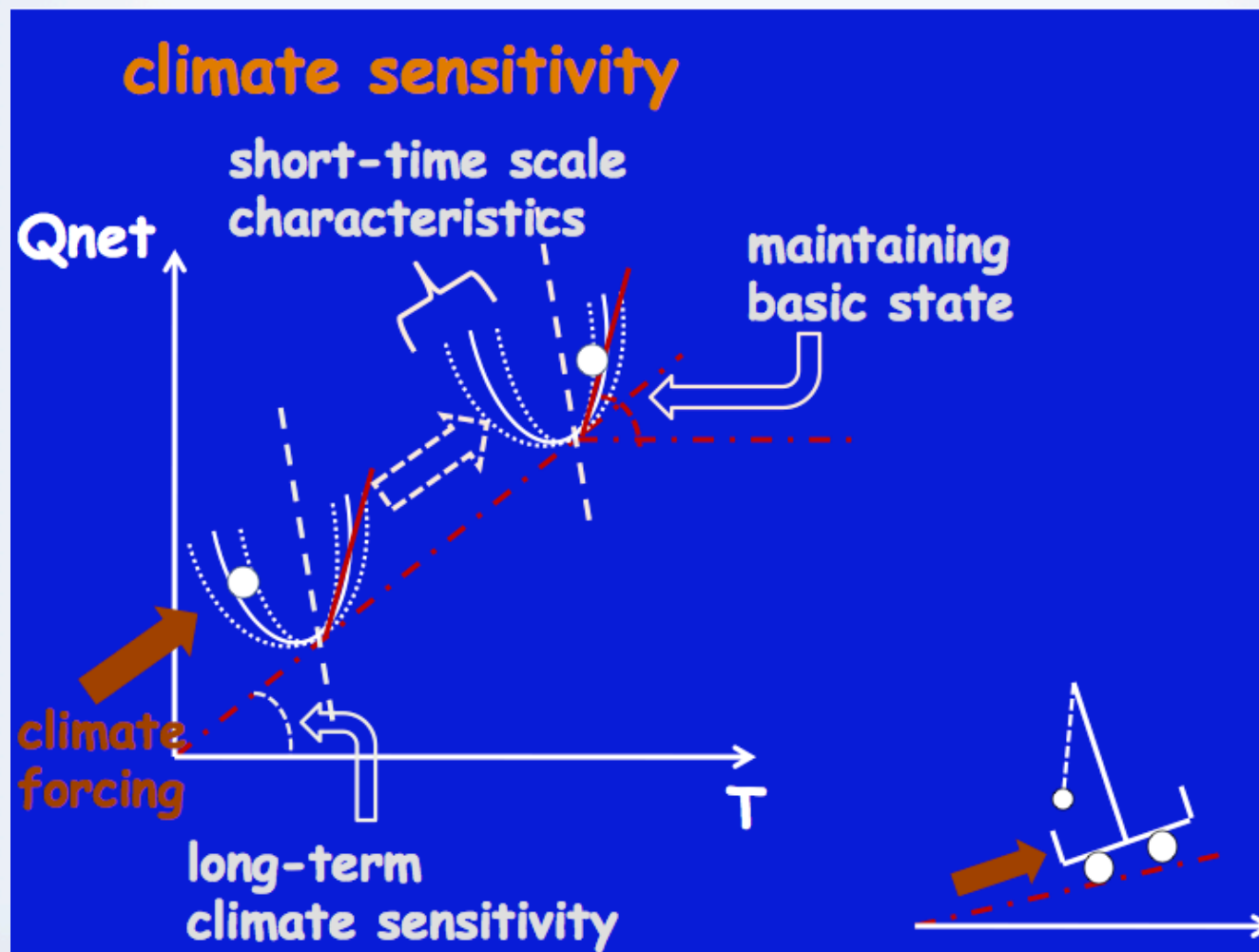
This is a **breakthrough study** that provides observationally-based method to reduce the uncertainties in climate predictions, especially in climate sensitivity and climate feedbacks. This study uses energy balance analysis to estimate the climate sensitivity. **The significance of current analysis is that top-of-atmosphere radiation and surface temperature observations are used as the basis for the estimations of climate feedbacks.**

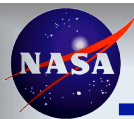
Additionally, historic climate variations and deep ocean heat transport are considered. This study results in a long time-scale (~ 100 years) of climate system for its changes and variations, which may suggest additional warming beyond what have been seen during last decade for future climate.



Lin – extra slide

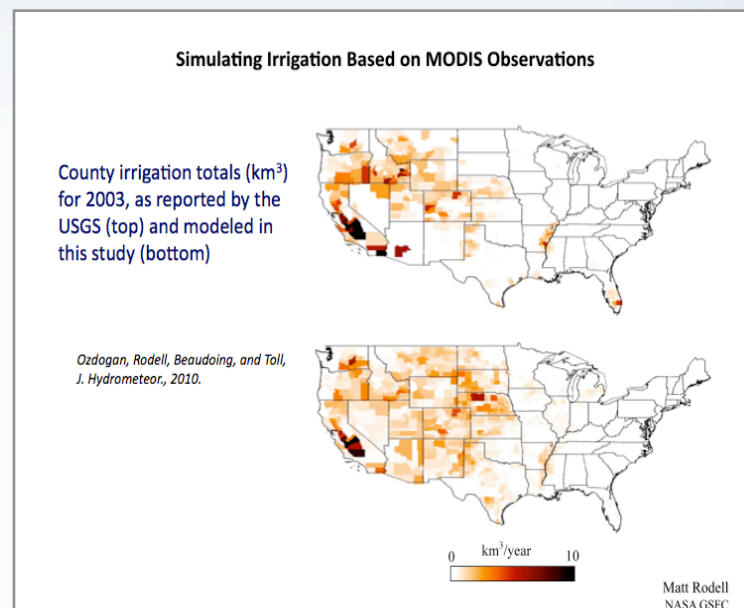
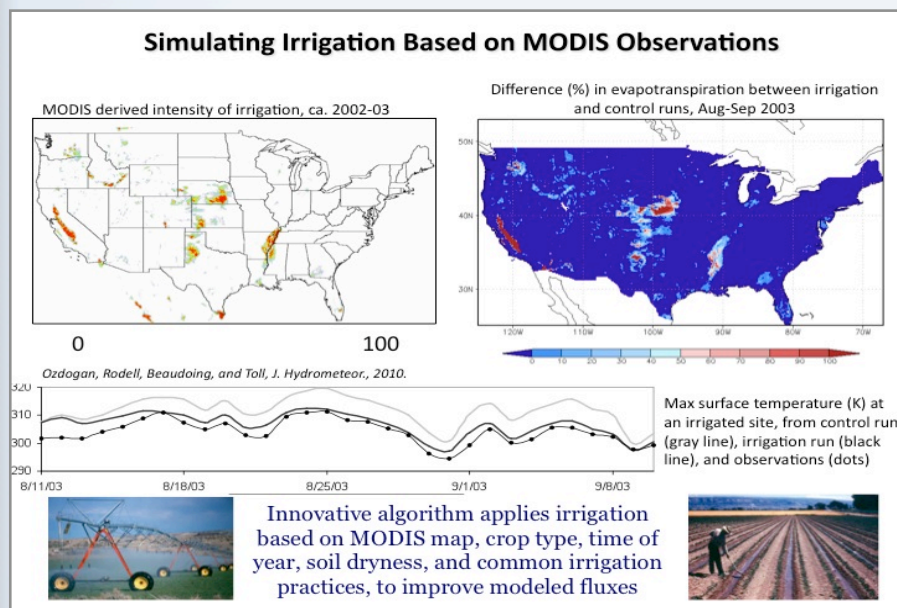
B. Lin, L. Chambers, P. Stackhouse Jr., B. Wielicki, Y. Hu, P. Minnis, N. Loeb, W. Sun, G. Potter, Q. Min, G. Schuster, and T.-F. Fan, Estimations of climate sensitivity based on top-of-atmosphere radiation imbalance, *Atmos. Chem. Phys.*, 10, 1923–1930, 2010. (Published: 19 February 2010)





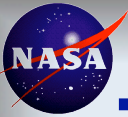
NEWS Publication Highlight

Ozdogan, M., M. Rodell, H.K. Beaudoin, and D. Toll, Simulating the effects of irrigation over the U.S. in a land surface model based on satellite derived agricultural data, *J. Hydrometeor.*, 11 (1), 171-184, doi: 10.1175/2009JHM1116.1, 2010.



This paper presents a novel scheme for representing irrigation in land surface models, which are the land component of weather and climate forecast models. We used a high resolution map of irrigation intensity derived from the Moderate Resolution Imaging Spectroradiometers (MODIS) aboard NASA's Terra and Aqua satellites. This we integrated into NOAA's land surface model at the scale of the continental United States. **Based on county irrigation totals reported by the USGS, we confirmed that the scheme reasonably estimated the amount of water irrigated.** We then showed that application of the new irrigation scheme significantly influenced the modeled surface water and energy balances. Irrigation caused a 12% increase in evapotranspiration and an equivalent reduction in the sensible heat flux averaged over all irrigated areas in the continental US during the 2003 growing season. Local effects were often much more extreme. **We expect that better representation of irrigation will lead to improved weather and climate forecasting skill when the new irrigation scheme is incorporated into numerical weather prediction models such as NOAA's Global Forecast System.** Further, the scheme will help to quantify the effects of irrigation on the global water and energy cycles.

2/26/10



Vertical Heating Structures Associated with the MJO as Characterized by TRMM Estimates, ECMWF Reanalyses and Forecasts

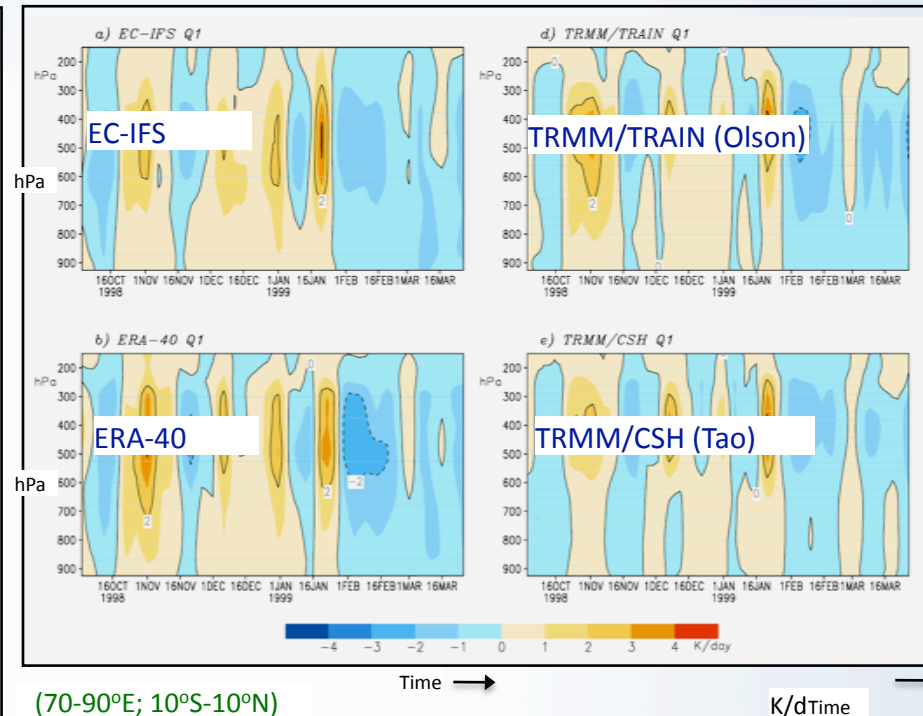
Integration work in progress

X. Jiang, D. Waliser, W. Olson, W.-K. Tao, T. L'Ecuyer, J.-L. Li, B. Tian, Y. Yung, A. Tompkins, S. Lang, M. Grecu

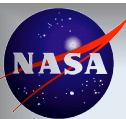
Motivation: The Madden-Julian Oscillation (MJO) exerts significant influences on global climate and weather systems. Current GCMs, however, are incapable of robustly representing this form of variability. To help address this challenge, in particular, considering the potential pivotal role of latent heating in the propagation and maintenance of the MJO, vertical heating structures associated with the MJO were analyzed by utilizing recently updated heating estimates based on the Tropical Rainfall Measuring Mission (TRMM) from two different latent heating estimates (Olson, Tao) and one radiative heating estimate (L'Ecuyer). Heating structures from two different versions of estimates based on the European Centre for Medium-Range Weather Forecasts (ECMWF) reanalyses (ERA-40)/forecasts (EC-IFS) are also examined.

Results:

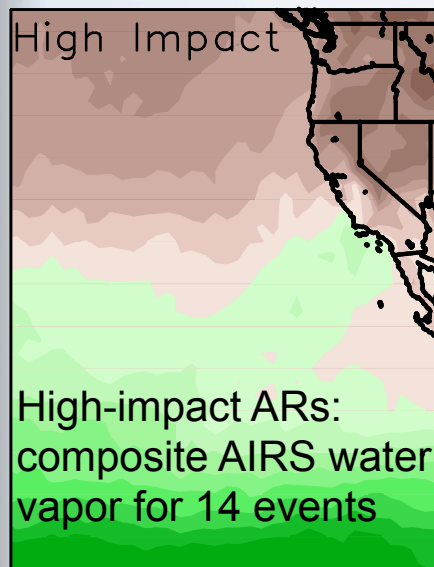
- (1) The results suggest that diabatic heating (cooling) associated with the MJO convection in the ECMWF outputs exhibits much stronger amplitude and deeper structures than that in the TRMM estimates over the equatorial eastern Indian Ocean and western Pacific. Further analysis illustrates that this difference might be due to stronger convective and weaker stratiform components in the ECMWF estimates relative to the TRMM estimates.
- (2) Despite marked differences in their seasonal mean fields, the vertical anomalous heating structures reasonably resemble each other based on the four products, including the amplitudes and vertical structures (see right).
- (3) Analysis illustrates that the stratiform fraction of total rain rate varies with the evolution of the MJO. Stratiform rain ratio over the Indian Ocean is found to be 5% above (below) average for the disturbed (suppressed) phase of the MJO.



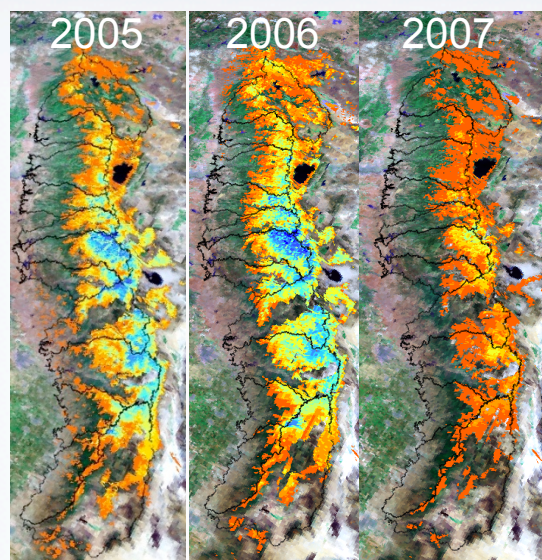
Time-pressure structures of anomalous heating (units: K day^{-1}) during the 1998/99 winter based on EC-IFS forecast, ERA-40 reanalysis, TRMM/TRAIN, TRMM/CSH estimates. All fields are averaged over the equatorial eastern Indian Ocean ($75-95^\circ\text{E}$; $10^\circ\text{S}-10^\circ\text{N}$). Anomalies are calculated with relative to their corresponding seasonal mean values during Oct. 1998 – Mar. 1999



Analysis links Atmospheric Rivers and Snow Accumulation in the Sierra Nevada



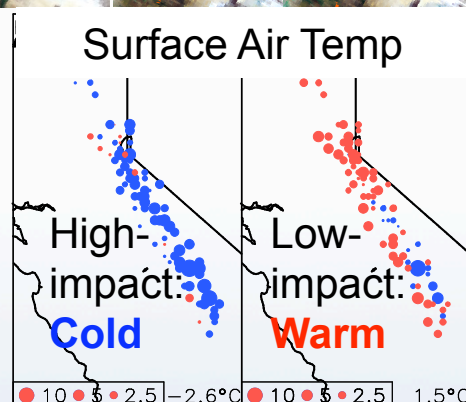
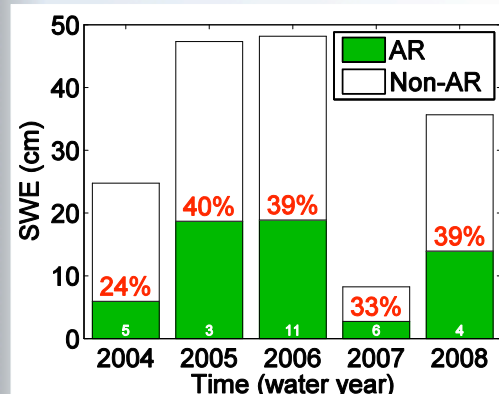
MODIS-model recon SWE



Problem: Atmospheric rivers (Ars) are narrow corridors of concentrated moisture in the atmosphere, and are a key process linking weather and climate. **ARs, typically a few events in a single winter, may result in up to ~40% of the total seasonal snow accumulation in the Sierra Nevada. It is not well understood what makes some events more influential than others.**

Result: Analysis of in-situ data reveals close connection between mountain surface air temperature (SAT) and amount of snow accumulation during ARs. Such connection is seen well tracked by NASA satellite AIRS (Atmospheric Infrared Sounder) L3 temperature retrievals.

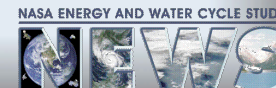
Significance: The result suggests potential utility of AIRS temperature products and the snow water equivalent (SWE) reconstruction product in understanding/predicting the impacts of landfalling ARs on water resources.

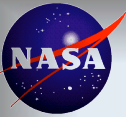


Guan, Molotch, Waliser, Fetzer, and Neiman, to be submitted to *GRL*

3/5/10

Waliser





Modeled downward radiative flux at the surface from the atmosphere increases due to CALIPSO CludSat derived cloud base

One of the improvements CALIPSO and CloudSat data provide is accurate vertical cloud profiles. The downward surface irradiance, especially longwave, is sensitive to the cloud base height. Active sensor (Calipso and CloudSat) derived cloud base heights increase the modeled global annual mean downward surface longwave radiative flux by 2 to 3% ($\sim 7\text{Wm}^2$) compared with the radiative flux computed without the active sensors; i.e. **the surface receives 2-3% more radiation from the atmosphere.** Because the global mean net surface radiative flux balances the surface latent and sensible heat fluxes and ocean heating, *it will reduce the uncertainty in the global surface energy budget.*

Figures 1 and 2 demonstrate the improvements. The change of the downward surface longwave irradiance is larger in midlatitude and polar regions because of small column water vapor amounts.

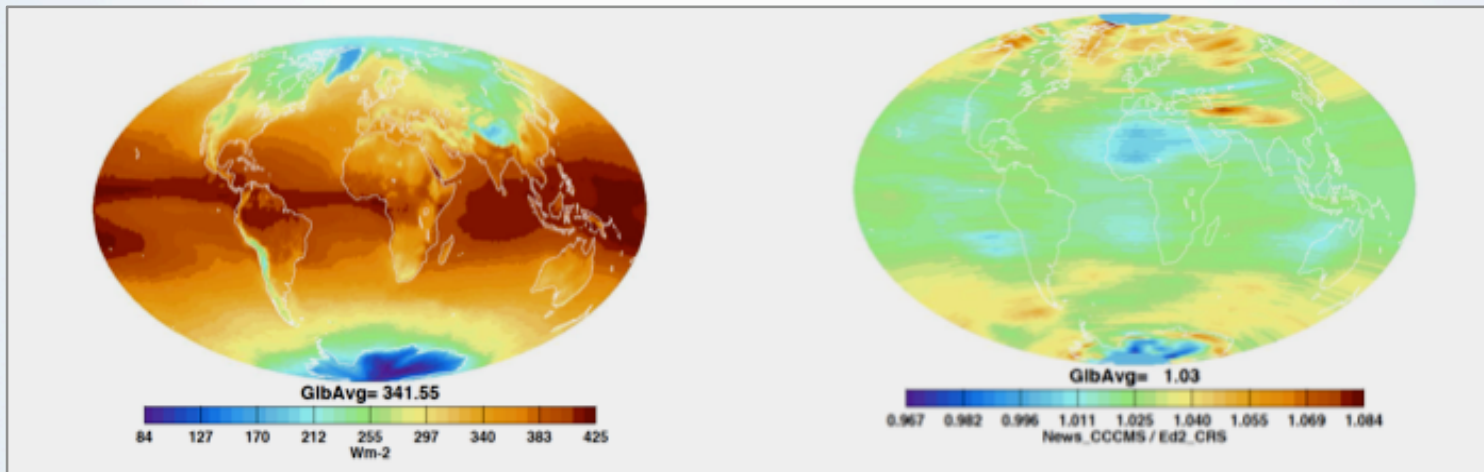


Figure 1: Annual mean (July 2003 through June 2004) downward surface longwave irradiance computed with MODIS derived cloud properties. GEOS-4 temperature and humidity profiles were used.

Figure 2: The ratio of the surface downward longwave irradiance computed with CALIPSO and CloudSat derived cloud vertical profiles to that computed with MODIS derived cloud only. **The global mean surface longwave irradiance increase by $\sim 30\%$ when CALIPSO and CloudSat derived clouds are used**



Are climate-related changes to the character of global-mean precipitation predictable?

The study suggests that the latent heat release due to changes in global rainfall is balanced primarily by the changes in radiative cooling by water vapor. Although water vapor may increase 6% per degree warming, the radiative cooling by increased water vapor only increased about 1-2% since the water vapor absorption line centers are saturated and the extra cooling is due to changes in the weak absorption part of the absorption spectrum. The theory agrees well with GCM results.

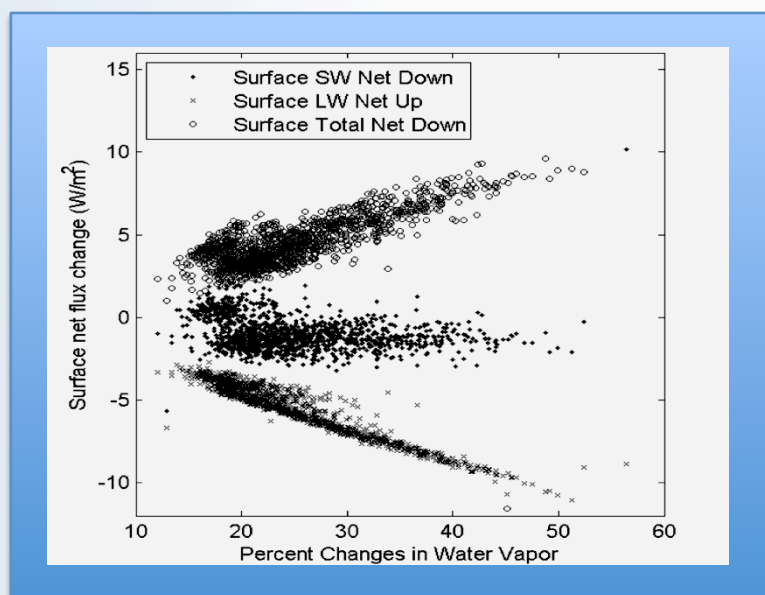


Fig.1: changes in net SW, LW and total (SW+LW) net surface fluxes as a function of the percent change in water vapor.

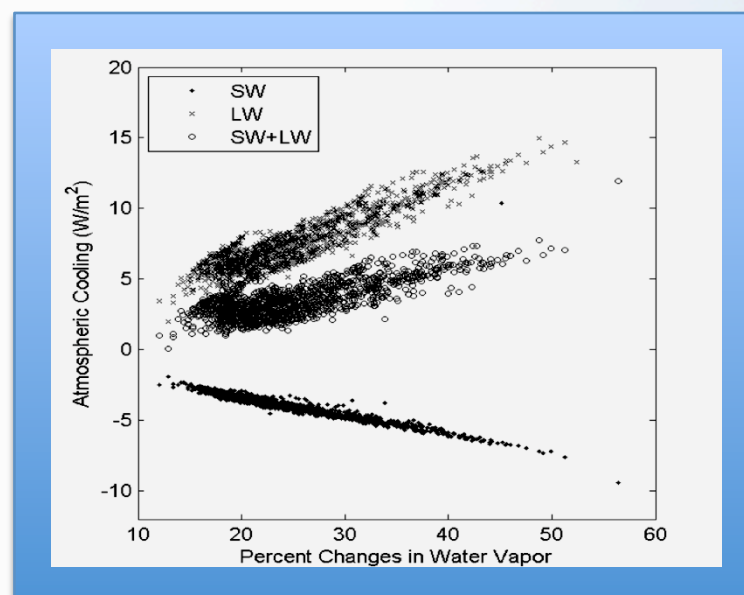
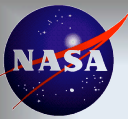


Fig.2: changes in net SW, LW and total (SW+LW) net surface fluxes as a function of the percent change in water vapor **but for a change in atmospheric radiative heating.** (Total LW radiative cooling is about 100 W/M^2)

G. Stephens and Hu, Y. (2010), Are climate-related changes to the character of global-mean precipitation predictable? *Environ Res Lett*, submitted.



Are climate-related changes to the character of global-mean precipitation predictable?

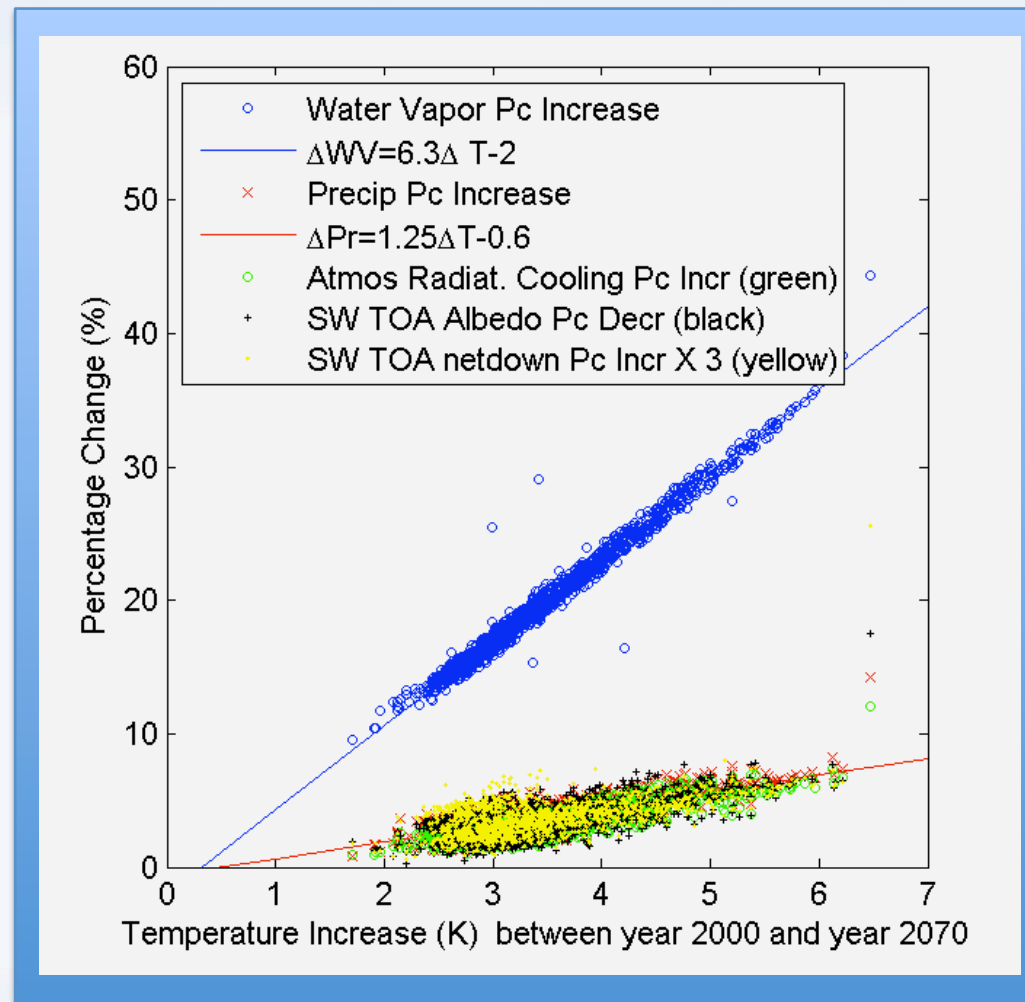


Figure 3. Water vapor at boundary layer (blue) increase about 6.3% per degree warming. Precipitation (red), atmospheric radiative cooling (green), TOA shortwave wave albedo (black) increase roughly about 1.25% per degree warming.



Diurnal Cycle of Summer Precipitation over US

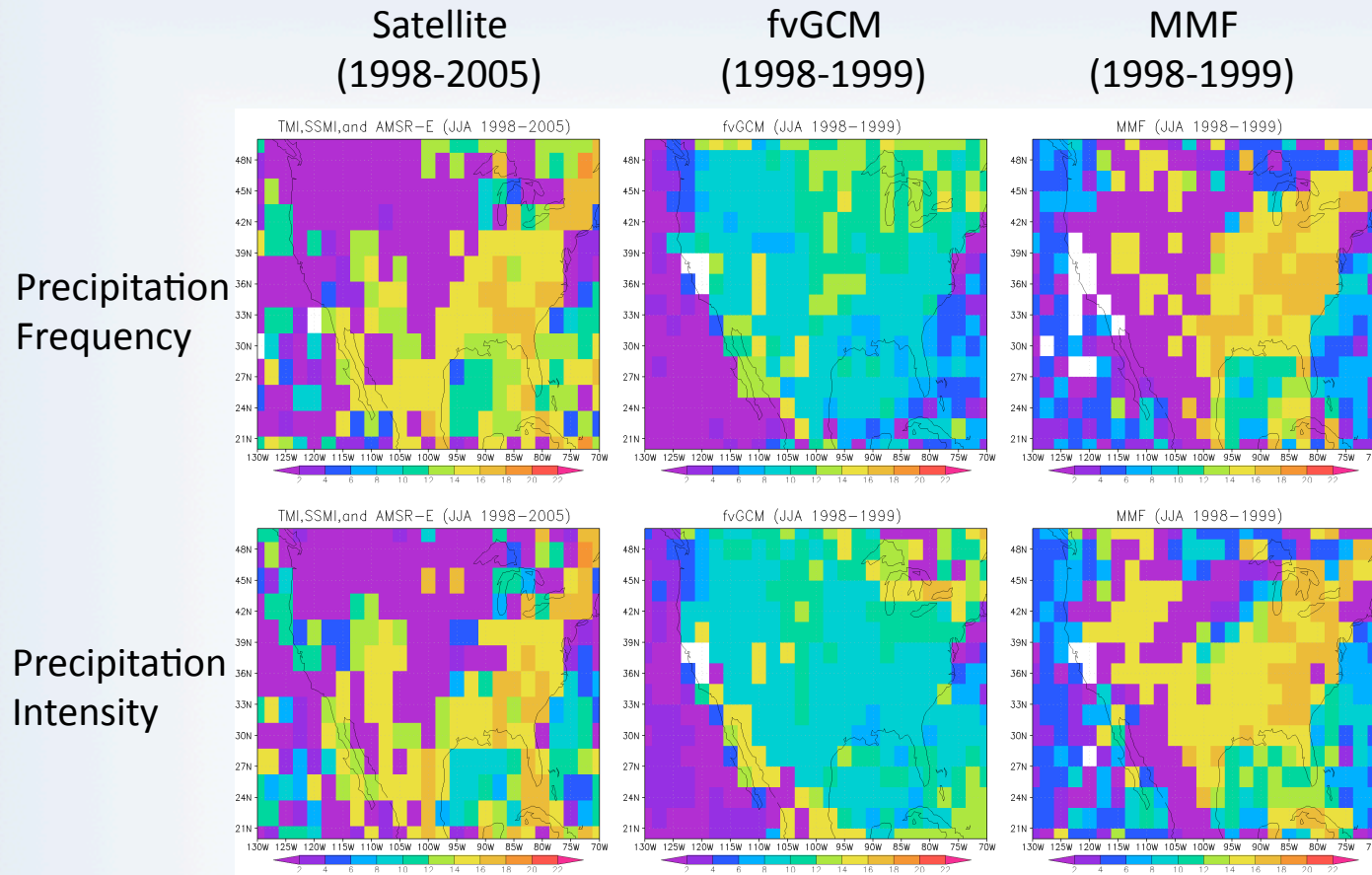
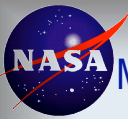


Figure. The diurnal cycle is a fundamental mode of atmospheric variability and has a major impact on weather and climate prediction. However most convective global models have a problem simulating the timing of diurnal cycle of precipitation. **The figure shows that multi-scale modeling framework (MMF) results substantially improve the timing of maximum precipitation frequency and intensity over the United States when compared with the merged microwave satellite observations.** (The color bar indicates the local time of the maximum rain frequency and intensity.)



Multiscale Simulation during Twin Tropical Cyclogenesis (TCs), a low pressure area, associated with a Large-scale MJO

- Accurate predictions of multiple tropical cyclones in location and timing would require a numerical model to simulate global water cycle realistically, as moist processes associated with precipitation and surface flux exchange provides the energy source that fuels the formation and intensification of TCs.
- *Figures below show **predictions regarding the formation of twin tropical cyclones in the Indian Ocean, demonstrating the modeling ability to do tropical cyclones** - key atmospheric processes to transport water and energy from tropical to mid-latitude, and modeled diurnal variation that almost all climate models cannot do.*

0630 UTC 1 May 2002

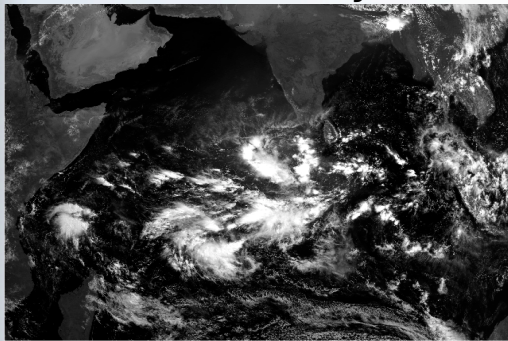
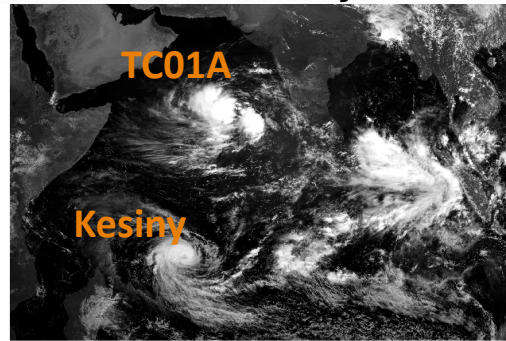


Figure 1: MJO-organized convection over the Indian Ocean at 0630 UTC 1 May 2002.

0000 UTC 6 May 2002



0000 UTC 9 May 2002

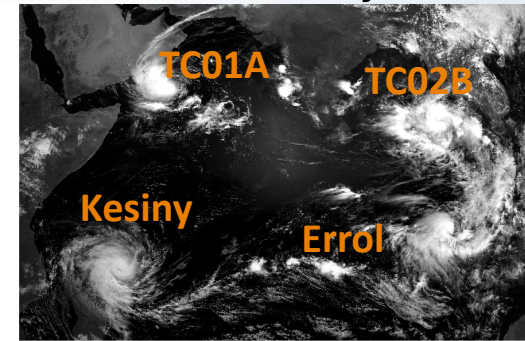


Figure 2 & 3: When the MJO moved eastward, two pairs of twin TCs appeared sequentially on 6 May (2) and 9 May (3), including TC 01A, Kesiny, TC 02B and Errol. Two TCs (01A and 02B) with anti-clockwise circulation appeared in the Northern Hemisphere, while two TCs (Kesiny and Errol) with clockwise circulation in the Southern Hemisphere

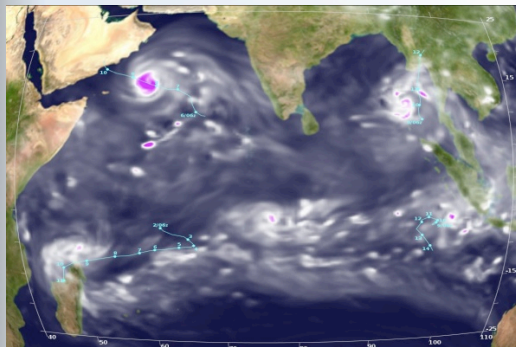
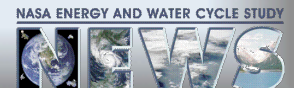


Figure 1 (left): Four-day forecasts of total precipitable water, showing realistic simulations of TC's formation and movement (see [Shen et al., 2010](#) for details).

Shen, B.-W., W.-K. Tao, R. Atlas, Y.-L. Lin, C.-D. Peters-Lidard, J.-D. Chern, K.-S. Kuo, 2009: Forecasting Tropical Cyclogenesis with a Global Mesoscale Model: Preliminary Results for Twin Tropical Cyclones in May 2002. (to be submitted)

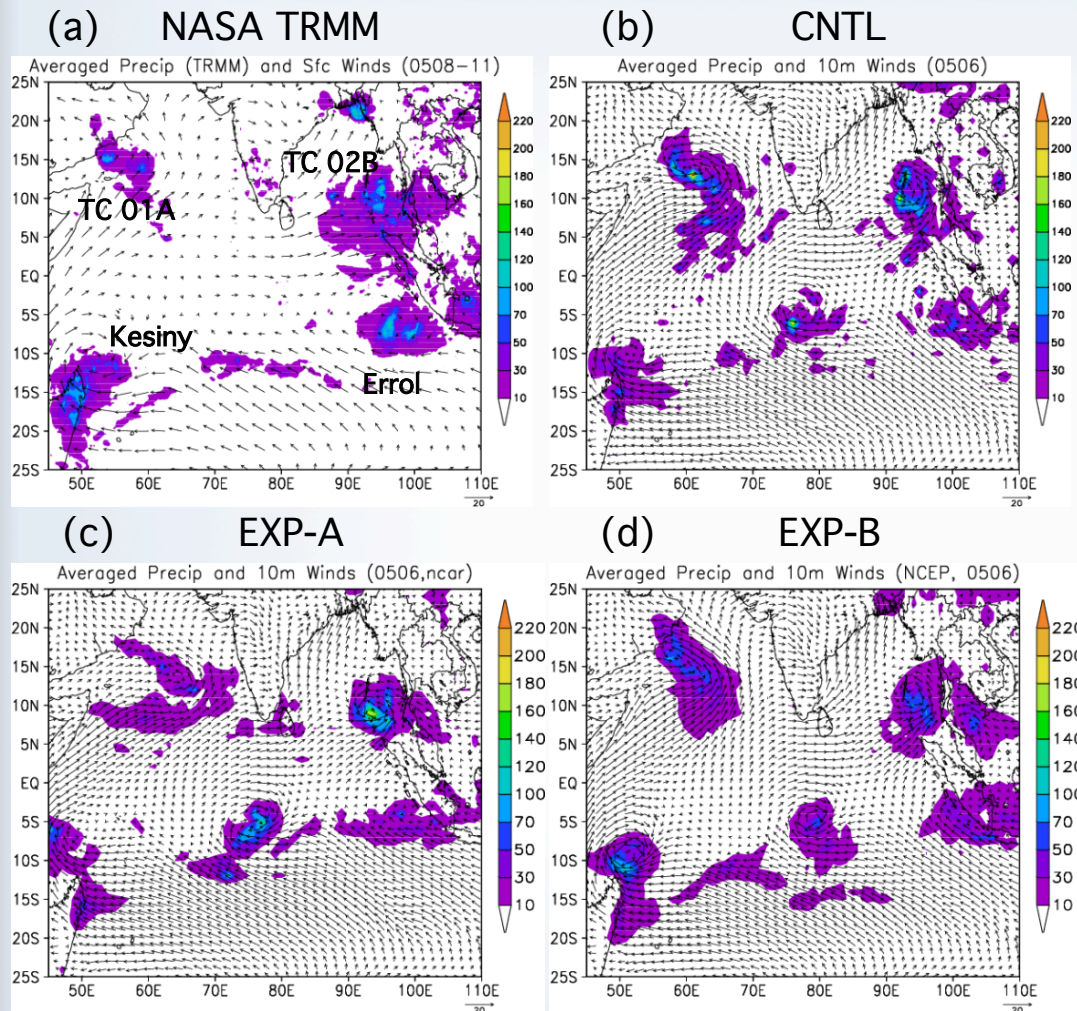
3/10/10

Tao





Precipitation Simulations associated with Twin Tropical Cyclogenesis

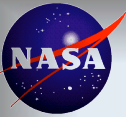


Precipitation (mm/day) averaged over May 8-11, 2002 from (a) NASA TRMM, (b) the control run (labeled as CNTL) and two parallel runs for (c) the exp-A run and (d) the exp-B run. All of three runs are initialized at 0000 UTC May 6, 2002 with different moist physical processes. Case CNTL has no cumulus parameterizations. Case EXP-A has Zhang and McFarlane (1995) and Hack (1994) schemes for deep and shallow- and-midlevel convection, respectively. Case EXP-B uses NCEP SAS (simplified Arakawa and Schubert) scheme (Pan and Wu 1995). The false-alarm event appears in all of three runs, suggesting missing physical processes in the model or imperfect Ics.

Shen, B.-W., W.-K. Tao, R. Atlas, Y.-L. Lin, C.-D. Peters-Lidard, J.-D. Chern, K.-S. Kuo, 2009: Forecasting Tropical Cyclogenesis with a Global Mesoscale Model: Preliminary Results for Twin Tropical Cyclones in May 2002. (to be submitted)

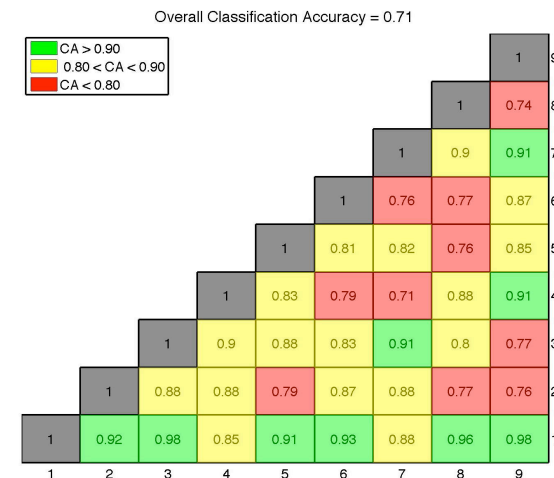
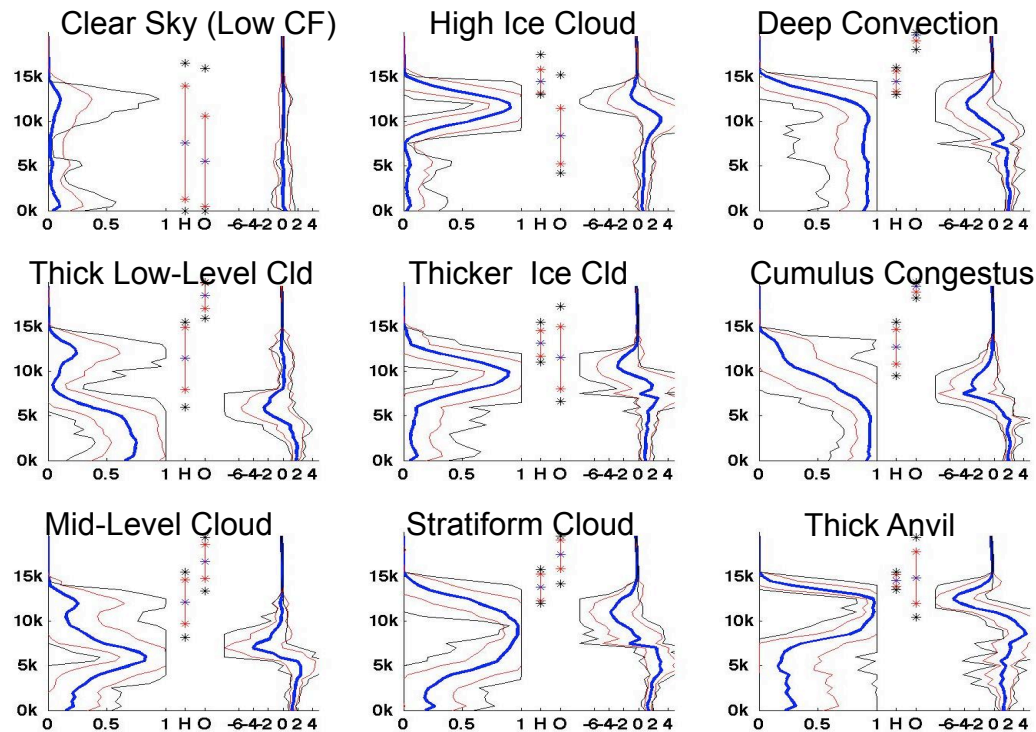
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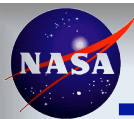




Determining Vertical Structure from Geostationary Satellite Data Using Cluster Analysis and Statistical Classification

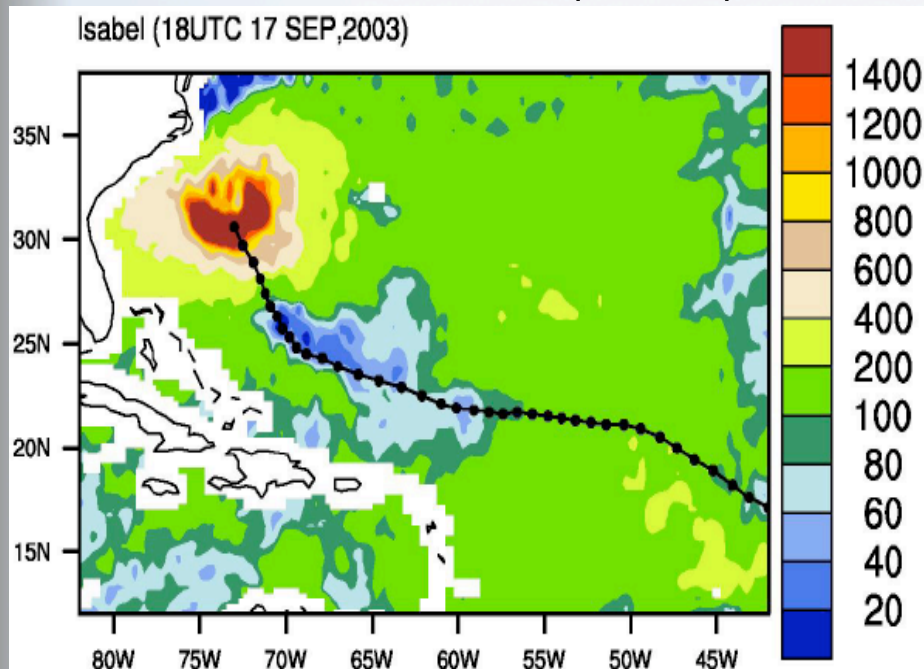
Knowing the vertical structure of clouds is an important element in understanding their radiative impact and is important for evaluating climate models. Cloud radars provide detailed view of cloud vertical structure but have limited spatial sampling while geostationary satellites have large spatial view but limited vertical information; combining them can produce cloud vertical information on large spatial scales. We used a clustering methodology to derive characteristic vertical structure of clouds and their heating profiles from ground radar observations (left). Classification matrix (right) shows geostationary satellite data plus simple information from reanalysis datasets can be used to predict which cluster an observation falls into ~77% of the time - indicating ability to predict vertical structure from geostationary satellite observations.



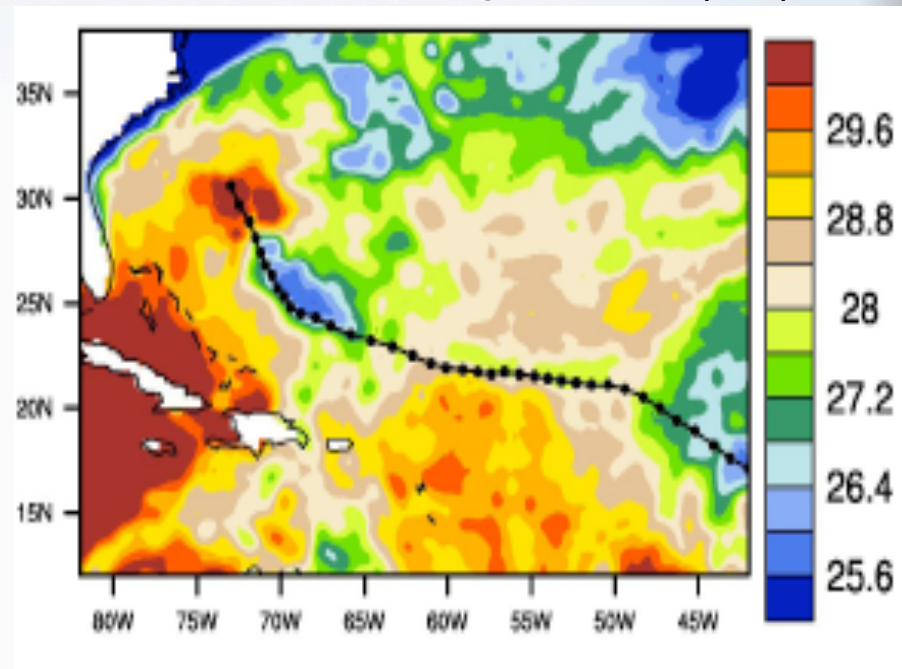


High-Resolution Satellite Surface Latent Heat Fluxes in North Atlantic Hurricanes

Latent Heat Flux (W m^{-2})



Sea Surface Temperature ($^{\circ}\text{C}$)

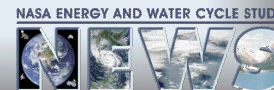


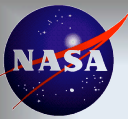
Satellite data sources: AVHRR, AMSR-E, SSM/I, TMI, QuikSCAT, AMSU-A

As part of the NEWS program, a new high resolution ocean surface latent heat flux data set has been developed that is capable of reproducing the extreme heat fluxes occurring in hurricanes. This snapshot of Hurricane Isabel shows the very high latent heat fluxes in the hurricane, plus the cold wake behind hurricane, and the vastly diminished latent heat fluxes. **This high-resolution dataset is being used to improve understanding of hurricane energetics and the impact of hurricanes on the upper ocean.**

4/2/10

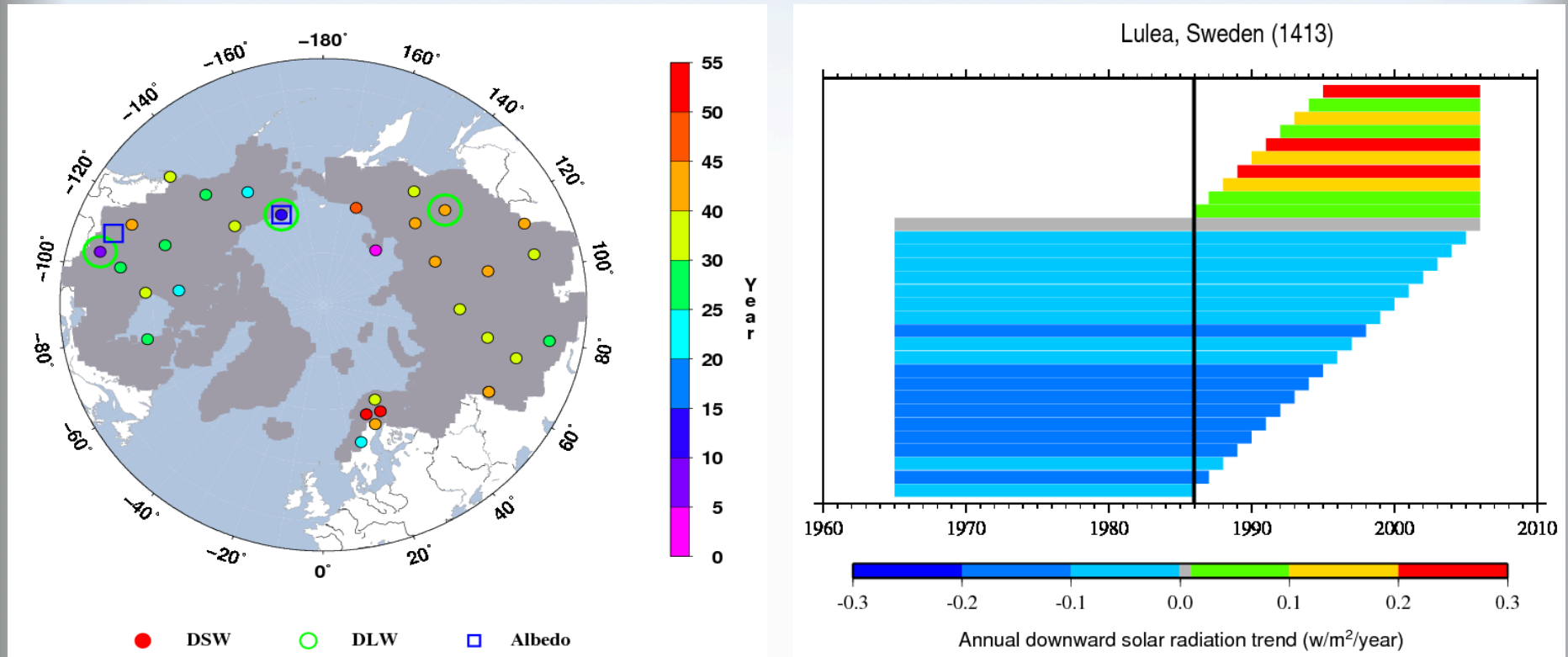
Curry, J. Liu, Clayson, Bourassa





Global Energy Balance Archive (GEBA) Downward Shortwave Radiation (DSW)

trend analysis over the Arctic: from Dimming to Brightening



32 DSW stations from **Global Energy Balance Archive (GEBA)**

No trend (1965~2006) = Decreasing trends + Increasing trends

Apparently, there is a turning point which is between 1985 and 1990 at these sites. Before that, a dimming period exists with decreasing trends, whereas brightening occurred thereafter. The role and importance of changes in surface solar radiation have been widely discussed, particularly with respect to documented changes in arctic snow cover. **This work offers a definitive evaluation of the nature of changes over the last 40+ years, and shows that while over the early part of the record, there was dimming, more recently there have been compensating increases, such that over the entire period, there is no net trend.**

4/2/10

Lettenmaier





MK trend test results for annual DSW observations

GEBA ID	Station Name	Start Year	End Year	Annual	
				<i>P</i>	Trend
396	Edmonton	1950	1987	<0.05	-0.16
442	Whitehorse	1971	1987	<0.01	-0.47
1413	Lulea	1965	2006	---	0.00
2104	Oestersund	1983	2005	<0.01	0.38
2492	Ekaterinburg	1964	1994	<0.05	-0.21
930	Turukhansk	1964	1995	---	-0.04
931	Olimyakon	1964	1992	<0.01	-0.36
932	Yakutsk	1964	1991	---	-0.07
933	Aleksandrovskoe	1964	1993	<0.05	0.30
936	Sverdlovsk	1964	1990	---	-0.01
937	Omsk	1964	1995	---	0.04
940	Irkutsk	1964	1993	---	-0.23

- Trend test: using Mann-Kendall/Sen Slope at a 5% significance level;
- Calculate trends for annual downward shortwave radiation (DSW) of 12 GEBA sites spanning the periods from the 1950s and 1960s to post-2000;



8 (4)



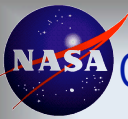
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3(2)

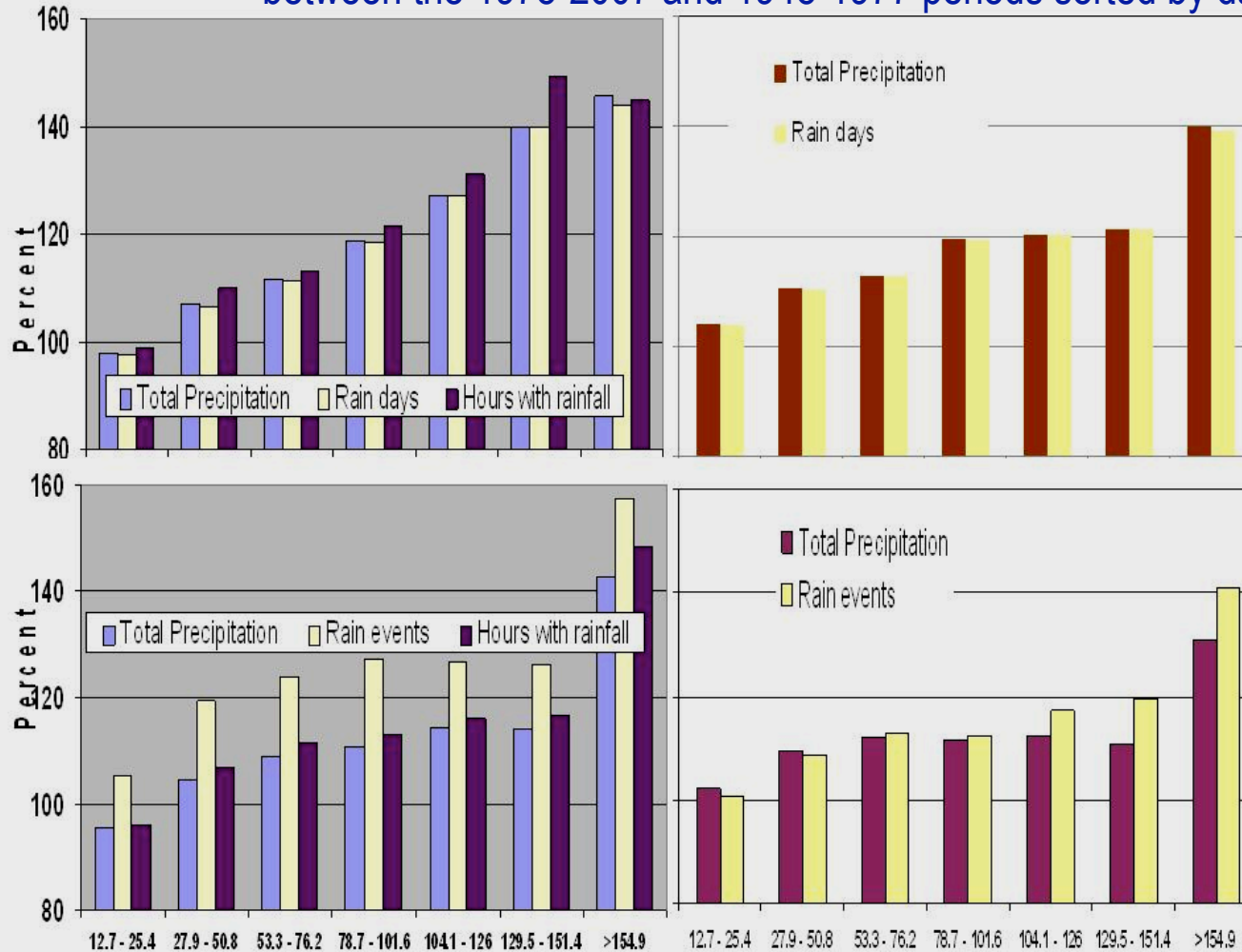


1

Lettenmaier



Comparison of intense precipitation days (upper line of plots) and multi-day intense precipitation events (lower line of plots) over the central United States between the 1978-2007 and 1948-1977 periods sorted by day/event intensities



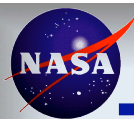
Intense precipitation (above 0.5") encompasses approximately two thirds of annual precipitation totals and about 20% of all rain days over the contiguous United States. In recent decades, high-intensity events (above 1") became more frequent over the nation and, particularly, over the central United States.

Information from studies such as this one may help assess the potential for disasters in the future, and would benefit farmers, politicians, water managers, insurance companies, construction companies... and other scientists.

On the x-axes, plots have the daily precipitation ranges, in mm, selected to accommodate the British units, inches (so, the first category, from 12.7 mm to 25.4 mm corresponds to 0.5" to 1", and the last above 6").

Results are based on two national U.S. data sets. Groisman *et al.* (2010)

4/2/10



NEWS Datasets Shed New Light on the Differences between the Northern and Southern Hemisphere Branches of the ITCZ



Principal Investigator: T. S. L'Ecuier (tristan@atmos.colostate.edu)

Science Question (Figure 1): TRMM observations show a year-round band of rainfall (called the Inter-Tropical Convergence Zone, ITCZ) just north of the equator in the tropical east Pacific (white box). Why does the second band of rainfall in the southern hemisphere only show up in March-May?

Relevance: More than two-thirds of the heat released in the Earth's atmosphere occurs in the tropics and the ITCZ, in particular, plays a central role in the global circulation and water cycle. The many competing explanations for north-south differences in the ITCZ are all based primarily on numerical models and need to be tested using observations.

Data Integration: This study combines several NEWS data products to determine which sources of ocean heating are responsible for the differences in rainfall north and south of the equator.

Significance: This study resolves the debate about the main sources of equatorial asymmetry using exclusively satellite-based datasets. It also provides an observational benchmark for testing future model predictions. Such tests are essential to increase confidence in future climate predictions.

Masunaga, H. and T. S. L'Ecuier, 2010a: "The Southeast Pacific Warm Band and Double ITCZ", *J. Climate* **23**, 1189-1208.

Masunaga, H. and T. S. L'Ecuier, 2010b: "Equatorial Asymmetry of the East Pacific ITCZ: Observational Constraints on the Underlying Processes", submitted to *J. Climate*.

5/3/ 2010

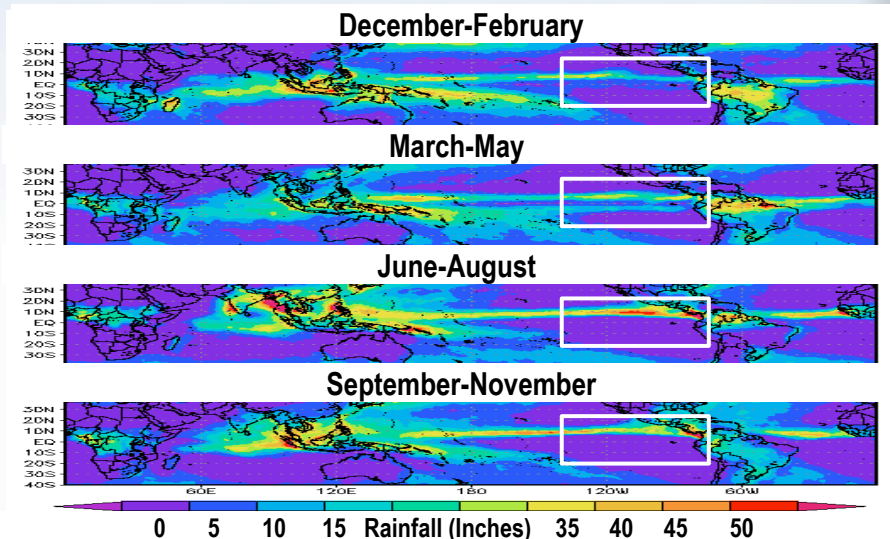


Figure 1: Average rainfall observed by the Tropical Rainfall Measuring Mission (TRMM) in the northern hemisphere winter, spring, summer, and fall seasons..

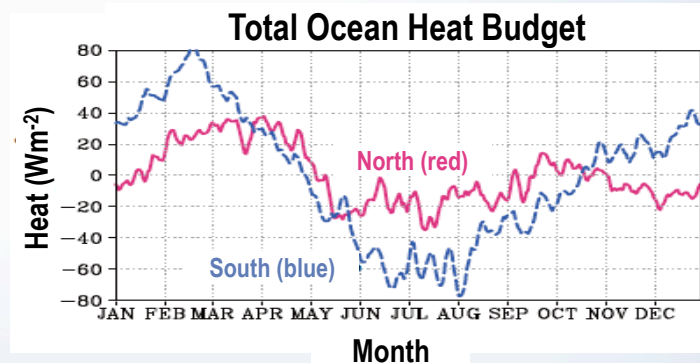
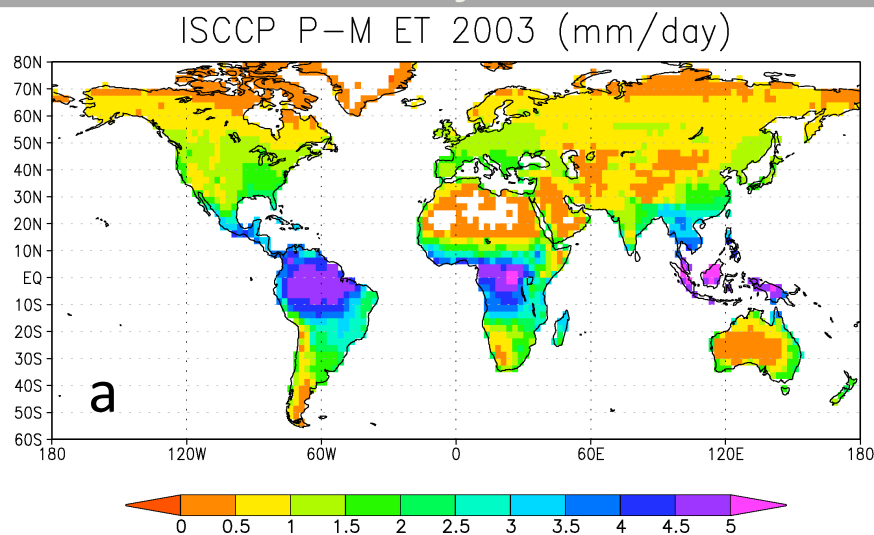


Figure 2: Satellite heating datasets indicate that the difference between the northern and southern hemispheres is caused by much stronger seasonal shifts in the southern ocean's heat budget (the sum of all sources of heating and cooling of the upper ocean). There are three main reasons for this: (a) the Earth is closer to the sun during the southern hemisphere summer months, (b) the ocean is slightly more efficient at absorbing sunlight south of the equator, and (c) increased sunlight during summer months north of the equator is offset by increases in cloudiness that reflect more of this sunlight back to space.



Development and diagnostic analysis of a multi-decadal global evaporation product for NEWS

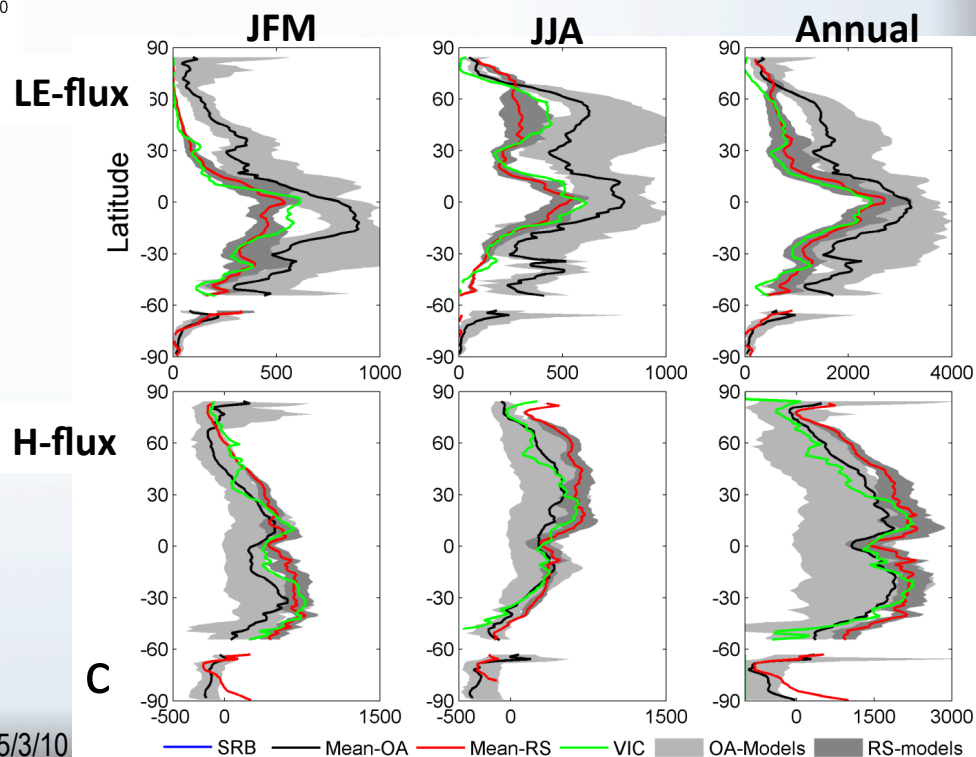
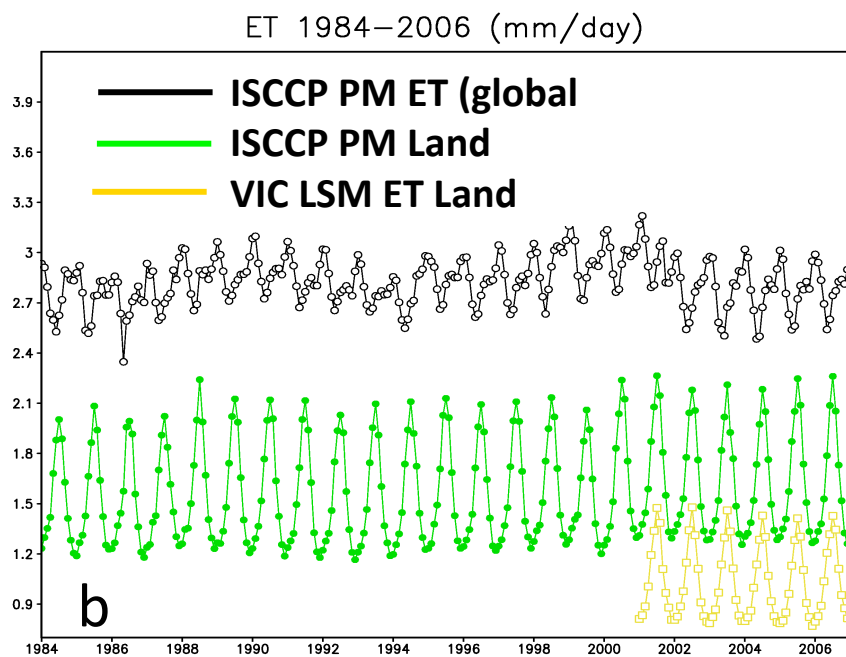
PI: Eric F Wood



Panel a: Annual terrestrial ET using the ISCCP data and a Penman-Monteith RS model

Panel b: 1984-2007 terrestrial and global ET estimates using PM/ISCCP. Note comparison to VIC LSM and global P ~ 2.8 mm/day

Panel c: Comparing remote sensing to operational models being assessed by NEWS



5/3/10